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CHAPTER 4 ELECTRICAL SYSTEMS

SECTION 4.1 INTRODUCTION

All Indiana rolling lift bascules have relatively modern electrical equipment. These electrical systems are also in generally good condition, although some functionality has been lost, including the tail locks which are no longer operating.

A typical electrical system for a movable bridge includes four major groups of equipment:

- Power Distribution Equipment
- Electrical Machinery
- Control System
- Lighting Systems

Conduits, flexible cables, junction boxes, electrical cabinets, and other components common to electrical systems are found on these bridges. An indispensible tool for the inspection of the bridge electrical system is the wiring or circuit diagram. These diagrams allow the inspector to determine the function of various components and what circuits control which functions. Common electrical systems and the tools unique to these inspections are discussed in this chapter.

SECTION 4.2 INSPECTION TOOLS AND INSTRUMENTS

Tools that are necessary for an electrical inspection include a megohmmeter, a voltmeter, a live power indicator, an ammeter, a thermometer, and a receptacle tester. The megohmmeter is a cable voltage insulation tester used to inspect bridge wiring, cables, and specialty cables. A voltmeter can be used to check the voltage on equipment and help verify equipment is de-energized. An ammeter can be used to verify the current and direction of phasing to motors, and verify desk indicators.

The inspector should note all equipment on the bridge and the state of the equipment. Each piece of equipment should have a unique identifier. This name should be used to track the status of the equipment from inspection to inspection.

An Electrical Inspection should be done in accordance with the recommendations listed in this manual, the American Association of State Highway and Transportation Officials (AASHTO) *Movable Bridge Inspection, Evaluation, and Maintenance Manual* and the National Electric Code (NEC). Part 5 of the Indiana *Bridge Inspection Manual* is intended to augment the inspector’s prior knowledge of the NEC by providing bridge-specific equipment information.

SECTION 4.3 POWER DISTRIBUTION EQUIPMENT

The power distribution equipment consists of electric power sources, protective devices, and distribution equipment.

The primary power source for movable bridges is a three-phase electric service from a local utility company. The typical three-phase electric service voltage used on the Indiana rolling lift bridges is a 277/480-volt, four-wire system.

The electric service from the utility company is delivered from pole-mounted or pad-mounted transformers typically owned and maintained by the utility. Feeders from the transformers extend to the service disconnect. The service disconnect is a circuit breaker or fused switch, owned and maintained by the bridge owner, which provides overload and short-circuit protection of the bridge electrical system. A utility energy consumption meter is located in the vicinity of the service disconnect or at the utility transformers.

A movable bridge electrical system may be provided with a secondary source of electric power should the primary electric source fail. To provide this redundancy in electric supply, a second electric service derived from a utility source independent of the primary electric service may be provided. The second electric service will be furnished with its own service disconnect and utility meter.

Electric power is supplied to the various motors and electrical equipment through protective devices, namely fuses and circuit breakers. Fuses and circuit breakers provide overload and short circuit protection to the electrical equipment they serve. These protective devices are typically housed in panel boards, motor control centers, and/or enclosed panels. Typically, fuses are cylindrical devices that prevent fault currents by melting and preventing any current flow. They are single use items and must be replaced when they have been used. Circuit breakers are used to protect the electrical equipment from a fault condition. Circuit breakers have elements that sense the current and are set to open the breaker if a certain limit is reached. Once tripped, the circuit breaker can be reset and used again.

A panel board contains a group of circuit breakers to distribute power to various electrical devices. Motor control centers house circuit breakers, fuses, motor starters, motor controllers, and other equipment required to control and distribute power to motors and other equipment. Motor control centers are modular in construction. In lieu of panel boards and motor control centers, circuit breakers, fuses, motor starters, motor controllers, and other motor control equipment may be installed on an enclosed, custom-built panel.

Transformers are commonly installed on movable bridges. Transformers convert voltage from one level to another, usually to serve lighting loads or to isolate electrical noise in the electrical system.

Electrical circuits are carried from panel boards, motor control centers, enclosed panels, and transformers to the electrical devices they supply power to through a raceway system. A raceway system typically consists of rigid, metal conduit and junction boxes. Electrical wires, or conductors, carry electrical current and are installed inside the conduit and boxes that make up the raceway system.

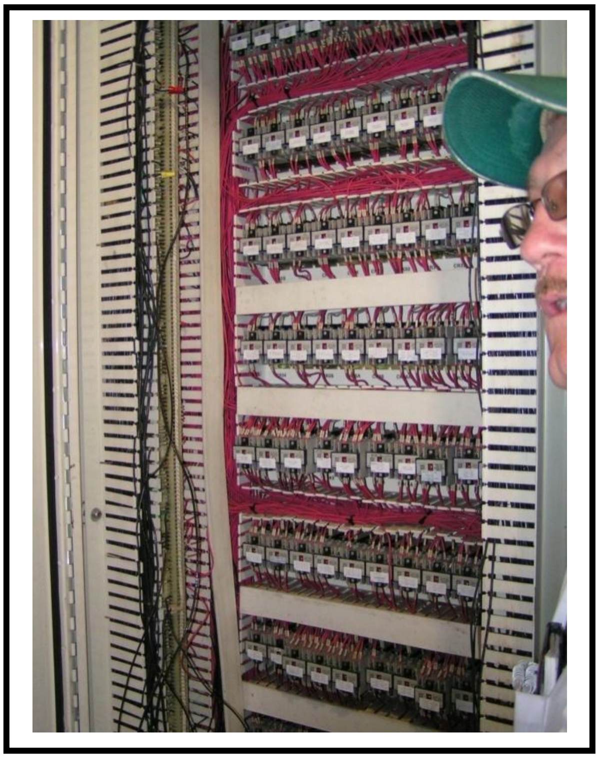

Figure 5:4-1: Dickey Road Panel Board

SECTION 4.4 ELECTRICAL MACHINERY

Electrical machinery refers to electro-mechanical devices that operate the movable span and auxiliary devices such as locks and traffic control equipment. For the Indiana rolling lift bridges, the electrical systems are designed with interlocks that prevent bridge operation without completing a pre-programmed sequence of operation. This fact must be kept in mind when inspecting the electrical systems for these bridges.

Subsection 4.4.1 Span Motors

The movable span is provided with one or more span motors that serve either as the prime mover for the span or provide the power to operate hydraulic pumps that are used to move the span. Span motors are the alternating current (AC) type on all Indiana bridges. Depending on the type of motor control equipment employed, the operating speed of the span motors is governed by the bridge operator or by a motor controller. A motor controller provides controlled motor speed and torque to ensure smooth movement of the movable span. The span motor and motor controller combination is commonly referred to as the electrical part of a span drive.

In an electro-mechanical drive system, the movable span is provided with electrically actuated span brakes to stop and hold the movable span. With modern motor controllers, the majority of braking during operation is accomplished by the span motor and motor controller. Thus, span brakes are typically utilized for holding the movable span and stopping it during emergency conditions.

Subsection 4.4.2 Auxiliary Motors

Some movable spans are equipped with a back-up motor for operation in the event the span motors fail or are out-of-service. These motors, called auxiliary motors, are generally smaller motors that take longer to open or close the span because of additional speed reduction gearing. The motor controller for an auxiliary motor is typically an across-the-line contactor.

The auxiliary motor will either be directly coupled to the main span machinery, or separated by a clutch. The auxiliary motor will either be selected by the operator at the control desk, or operated locally. The clutch, if present, will then be operated manually or electrically to connect the auxiliary motor.

Subsection 4.4.3 Locks

Locks are described in detail in Chapter 3, Section 3.3, Stabilizing Machinery. The electrical equipment is similar in each type, consisting of a motor directly coupled to the machinery and a series of limit switches to monitor the machinery. The motor controllers for locks are typically across-the-line contactors.

Subsection 4.4.4 Warning Gates and Barrier Gates

Traffic signals, lights, and gates are used to warn approaching cars and pedestrians and to provide physical protection, when required. Traffic signals, or red flashing lights, are used to initially stop the traffic. Once the traffic has come to a complete stop, the warning gates are lowered to indicate that no vehicles may enter. Gates are usually equipped with flashing lights.

Subsection 4.4.5 Gongs, Horns, Bells, or Sirens

Gongs, horns, bells, or sirens are used to alert traffic to changing conditions. They are sounded at the beginning and end of any bridge operation and used in tandem with flashing lights and warning signs.

SECTION 4.5 CONTROL SYSTEMS

The control desk is where the bridge operator controls the operation of the bridge and its associated equipment. There are push buttons, control switches, indicating lights, meters, and indicators on the desk, and often a foot pedal switch mounted on the floor at the control desk. Mirrors, cameras, and binoculars are used to help the operator see motor, pedestrian, and water traffic.

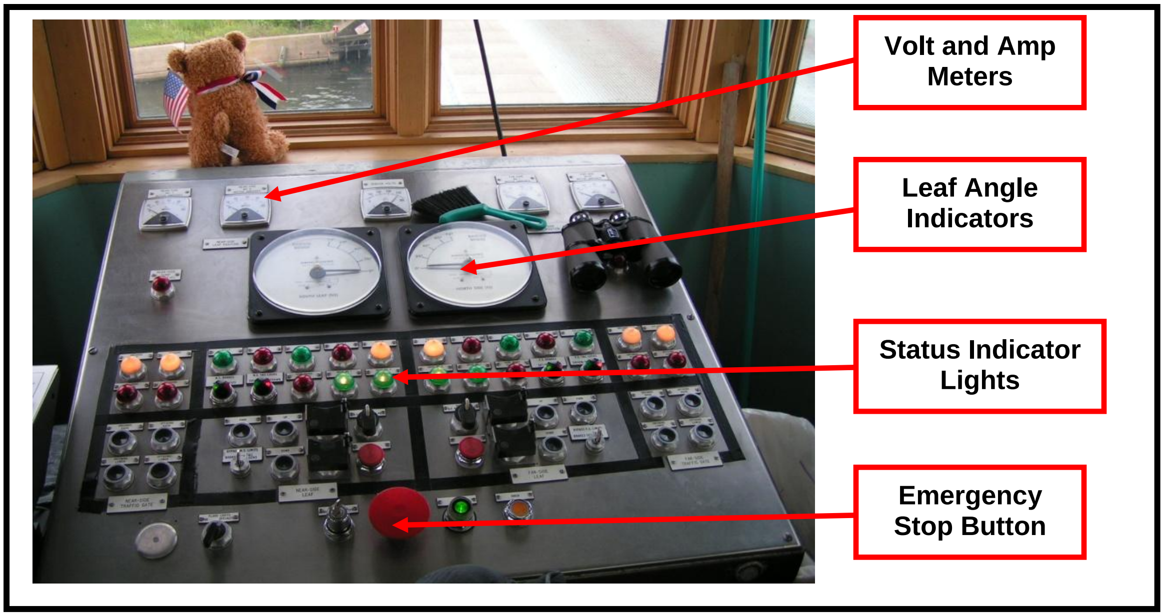

Figure 5:4-2: Franklin Avenue Control Desk

There are many types of motor controllers, ranging from simple contactors to motor drives. The equipment may be installed in a panel or motor control center.

A standard motor controller consists of a motor protector, a contactor, and a motor overload device. A motor circuit protector is either a circuit breaker or a fuse that has a trip setting to protect the motor controller and motor. Contactors are devices that make or break current to the motor. When the motor is connected to the current, it will operate, and when the current is removed, it will stop. Contactors can operate the motor in a single direction, or forward and reverse directions. An overload device is a sensitive, quick-acting device that will sense when the motor is drawing too much current and open the contactor to stop the motor. Motor overloads are intended to be faster in reacting to a motor fault than a circuit breaker or fuse, and more sensitive to minor faults that would not trip a circuit breaker.

Many specialty controllers, called motor drives, provide the same functions listed above, as well as speed, torque, and/or counter torque control of the motor. Motor drives use circuit boards and capacitors to generate a specific current amplitude and/or frequency to control the motor.

Limit switches provide an electrical signal to stop or change operation. There are several types of limit switches: lever arm, plunger-type, rotary, and proximity.

Relays are low-current switching devices that provide logical control of a bridge. They can be used independently or with a programmable logic controller (PLC). In order to provide control for an entire bridge, multiple relays are required. They are generally located in a panel or enclosure. When relays are used with a PLC, they are generally interposing relays. These relays are located between the PLC outputs and the equipment being controlled and serve as a means of isolation. Relays are also used as part of auxiliary systems, such as traffic gates, or control of local equipment.

Machine relays are larger relays that can be repaired and modified for various logical configurations. They are bolted to panel back plates and the terminals of the relay accept wire. “Ice cube”-style, plug-in relays are smaller relays covered with a clear plastic cover. They cannot be modified or repaired and must be replaced when damaged. They are plugged into a mounting strip and wires to the electrical equipment are terminated on the mounting strip.

Check all contact surfaces for signs of pitting or flashing. Contacts should not make any sounds.

PLCs are computers that provide the logical control of the bridge. They are generally rack-mounted in cabinets in the control room. There may be multiple PLCs in the cabinet and multiple input/output (I/O) cards in the rack. There may be multiple remote I/O drops. A remote I/O drop will consist of I/O cards and communication cards rack-mounted in a panel. PLCs processors can use communication networks to transmit information from a remote drop to the main processors.

The PLC generates electrical control signals through the PLC output cards. These output signals interface with the motor electrical controllers and equipment to control bridge equipment. PLC input cards supply the PLCs with information on the state of the equipment and provide the necessary interlocks for the processors to start and stop the bridge equipment.

Figure 5:4-3: Control Relay Labeling on Dickey Road Panel Board

SECTION 4.6 LIGHTING SYSTEMS

Service lighting and receptacles are provided throughout the bridge to enable work and inspection in dark areas or at night. Check that receptacles exposed to the elements are provided with covers and have ground fault circuit interrupters (GFCIs) as part of the outlet.

Navigation lighting and signals are provided to guide and alert the channel water traffic. Red lights mounted on the piers or fenders mark the channel for the boats. Alternating red and green lights mounted on the span notify the boat operator of the status of the bridge opening. When the light is red, the span is not fully open. When the light is green, the span is fully open. Navigation lights are installed in accordance with U.S. Coast Guard standards and guidelines. Proper maintenance of these lights is essential for the safety of the waterway traffic.

An air horn or similar audible device is used to warn the water traffic that a bridge operation is about to start.

SECTION 4.7 INSPECTION OF POWER DISTRIBUTION EQUIPMENT

Inspection of the electrical service should include the following:

- Locate all points of electrical service. Some bridges may have separate points of service on each side of the bridge, or separate services for special equipment such as roadway lighting.
- Contact the utility and arrange for power to be disconnected. Have the utility verify, in the presence of the inspector, that electric power is removed.
- Perform a visual inspection of the incoming feeders. If the feeders are from overhead transmission lines, they can be easily viewed. Underground feeders will not be visible except at the point of entry.
- Check for damaged wires and missing or broken supports.
- Verify that all equipment is firmly mounted.
- Check for blown line jacks.
- Inspect the panels where service is terminated for damage, rust, debris, or fluid build up.
- Check the wiring and terminations.
- Check the insulation resistance of the cables while they are de-energized.
- Look for any scorch marks or evidence of faults in the panel.
- Inspect the main ground terminal. Request that the utility take a measurement of the resistance to ground to verify that the incoming service is solidly grounded.
- Inspect the bridge grounding system thoroughly if the grounding at the utility is not acceptable.

Inspection of the transformers should include the following:

- Inspect the exteriors for damage, corrosion, lost paint, or scratches.
- Verify that the hinges and latches of panel doors or bolt on covers operate properly, are sufficiently lubricated, and make a tight seal when the doors/covers are sealed.
- Verify there is a gasket between the door/cover and the panel. The gasket should be continuous, springy, and compressible to the touch. Note if the gasket is brittle, permanently deformed, or missing in areas.
- Verify that the panel mount is secure and vibration-resistant. The panel may be free-standing and bolted to the floor, wall-mounted and bolted to the wall, or wall-mounted and mounted to a metal strut support.

- Note any loose bolts or other deficiencies.
- Listen to the transformer for any unusual noises during bridge operations. Transformers normally have a low, quiet, buzzing sound.
- Take the temperature of the transformer and compare it to the specified normal range. Record the operating temperature.
- Inspect oil-filled transformers for leakage.
- Test older transformers for polychlorinated biphenyls (PCBs).

Motor control centers (MCCs) are cabinets where electrical power is controlled and distributed to end devices. Equipment is arrayed in units called buckets. Each bucket will contain one or more of the following: an overcurrent protection device, a motor controller, an overload relay, or metering equipment. Inspect the panel, motor controllers, circuit breakers, fuses, and wiring.

Panel boards are panels with distribution circuit breakers and, on older bridges, relays. Inspection of the panels should include the following:

- Inspect the panel, circuit breakers, and wiring.
- Inspect the exterior of all panels for damage, corrosion, lost paint, or scratches. Inspect panel doors or bolt-on covers to verify that the hinges and latches are properly lubricated and make a tight seal when the door or cover is sealed.
- Verify there is a gasket between the door/cover and the panel. The gasket should be continuous, springy, and compressible to the touch.
- Note if the gasket is brittle, permanently deformed, or missing in areas.
- Verify the panel mount is secure and vibration-resistant. The panel may be free-standing and bolted to the floor, wall-mounted and bolted to the wall, or wall-mounted and mounted to a metal strut support. Note any loose bolts.
- Determine if any temperature control equipment, such as a heater, ventilation grate, and/or fan is operating properly. Verify that the ventilation grate filter is clean and free of dust and debris.
- Check that each panel is solidly grounded by a conduit fitting or ground bar located in the panel.
- Inspect other equipment located within the panel.

The raceway system consists of conduits, conduit fittings, junction boxes, and terminal boxes. Conduit is used to protect wire and route it from one location to another. Typically these are 10- or 20-foot sections of rigid galvanized steel (RGS) conduit, polyvinyl chloride- (PVC-) coated RGS conduit, and PVC nonmetallic conduit. Inspection of the raceway system should include the following:

- Ensure raceways are properly coupled and supported.
- Ensure all conduit is tightly connected. If a coupling becomes loose, the conduit sections may separate, and the wires inside may become damaged.
- Verify that required supports are present and securely mounted. Check each support for loose screws or bolts. RGS conduit should have secure support at intervals not exceeding 10 feet. Nonmetallic conduit should have a support every three to seven feet.
- Check the wall-mounted conduit runs for dirt and debris between the conduit and the walls. Dirt and debris should not be allowed to build up on any conduit runs.
- Note any areas that require cleaning.
- Check that conduit fittings are in good condition. Conduit fittings are in-line enclosures in conduit that provide bends or taps in conduit runs. Check the gaskets for a tight seal. Check the conduit fitting for any debris or fluid.
- Check that junction and terminal boxes (enclosures for the routing of wires) are in good condition. The boxes will be rated by the National Electrical Manufacturers Association (NEMA) for various exposure conditions, including watertight, dust-proof, and corrosion-proof. For all junction and terminal boxes:
    - Inspect the wires and terminals.
    - Verify that that seals around the access panels provide a watertight seal.
    - Check the boxes for debris or fluids.
    - Check that the drain and breather valves are operational.
    - Check the exterior of the boxes for rust or chipped paint.
    - Check the conduit bushing and fittings to verify a solid and tight fight.
    - Verify that any grounding fittings are properly installed and the ground wire is bonded to the fitting.

Bridge wires are copper conductors that carry electrical power and control to the electrical devices. Occasionally, aluminum is used in lieu of copper. Wires are either solid cylindrical shapes, or composed of several strands. Conductor sizes are based upon the amount of electrical current, or ampacity, of the load device. The more current required, the larger the conductor. The wire is covered with insulation, rated for electrical voltage, and jacketed to protect the wire. A cable contains several insulated wires within the same outer jacket. The insulation and jacket are selected based upon the electrical voltage of the system and the environmental conditions to which the wire/cable will be exposed. Inspection of the wire and cable should include the following:

- Confirm that the bridge is wired in accordance with the as-built documents of the electrical system. Each wire should be designated with a wire number that is referenced on the as-built drawings.
- De-energize high- and medium-voltage cables before inspecting. Only personnel trained on such equipment should perform the inspection.
- Check for insulation failure when the jacket and insulation of the conductor wears away, causing electrical faults or wire failure. Failure may be caused by overloading, physical wear and tear, exposure to water or corrosive materials, or age.
- Note any signs of abrasion or cracking over the entire length of the cable.
- Note any signs of discoloration and overheating.
- Note any signs of excessive bends or kinks in the wire.
- Note any signs of water or other moisture on the cables.

Wires and cables are usually installed in conduits. The conduits provide additional protection for the cables. When the cable is inside conduit, it cannot be visually inspected for the entire run. The wire and cable should then be inspected at accessible points, such as conduit fittings, terminal and junction boxes, and equipment panels.

Wires and cables are terminated at terminal strips in panels and lugs on equipment. There are three types of terminations to terminal strips: compression, fork-tongue, and ring-tongue. A compression terminal is simply a screw that presses onto the bare wire to make a contact. A fork-tongue or ring-tongue terminal is compression-clamped onto the wire. The screw in the terminal strip will compress onto the tongue portion. Vibrations that occur on a bridge will cause the terminals to loosen over time. Compression terminals traditionally have the least resistance to vibration and the wires may become loose. Ring-tongue terminals provide the best resistance to vibration, as the compression screw travels through the ring on the cable. If the screw becomes loose, the ring will still maintain contact.

The inspector should examine the terminations and note:

- Loose terminals.
- Any wires not tagged with a wire number.
- Any wiring not in accordance with the as-built drawings.
- Terminals not marked with the wire number of the terminated wires.
- Any movement or vibration between the panel and wires.
- Corrosion or rust on the terminals.
- That the exposed copper conductor will not come into contact with exposed metal.
- That the wire is isolated from power and sensitive equipment and perform an insulation megohm resistance to ground test on each individual wire. Record the wire number and the phase-to-ground resistance, and a phase-to-phase resistance with an adjacent disconnected wire in a table. If the resistance value is below one kilo-ohm, the wire is close to failing. If the resistance is zero, the wire has failed. Compare the results to previous results to determine if there are trends in the insulation resistance or the cable test results. This may indicate a problem in the run of wire.

Specialty cables, including flexible cables and submarine cables, are installed in areas that cannot be serviced by wire in conduit. Flexible cables are cables routed between fixed portions and movable portions of the bridge, such as cables from the rest pier to the bascule leaves. Flexibility comes at the cost of reduced jacket protection. In order for the cables to bend and move with the bridge, the jacket must be softer and more flexible. This means that they may wear more quickly from rubbing and abrasion.

Submarine cables are cables that are routed into the channel through the water from one side of the bridge to the other. The cables are usually trenched into the riverbed. They are exposed to a much harsher environment than regular cables. The portions of the cables that remain continually underwater, or continually out of the water, usually remain undamaged. The portions of the cables that are exposed to fluctuations in water level due to wet and dry periods, and the wear and tear of moving in response to the changing water level, require the closest inspection. Submarine cable is typically manufactured with a steel armor wire wrapping and polyethylene covering to protect it from the harsh conditions. Submarine cables are usually terminated in panels where the wiring is transitioned to normal wire and conduit.

The inspection of specialty cables should include the following:

- Check that the armor is terminated and grounded at the submarine cable terminal panels in special fittings.
- Verify the range of motion of flexible cables during an operation of the bridge. Cables should swing freely and move freely during the entire operation of the bridge.
- Check for sharp bends or kinks in the cables during operation.
- Note any cables that snag or rub against the structure or equipment.
- Test the insulation of the individual wires of the flexible cables using a megohm meter and record the values.
- Note the effects of wind on the cables during operation.
- Check the cable grips and supports at each end of the cables. They must have a firm grip on the cables and be solidly attached to the structure.
- Inspect submarine cables during low-water conditions if possible.
- Note any deterioration of the cables.
- Verify panel terminations and cable supports.
- Inspect the clamps of armored cable to make sure the cable is supported and grounded.
- Use a megohm resistance test to check the insulation of the individual wires of the submarine cables and record these values.

SECTION 4.8 INSPECTION OF ELECTRICAL MACHINERY

The inspection of all motors should include the following:

- Verify that the motor shaft is free from oil and grease from the bearings. Leaking oil can indicate a poor seal or misalignment of the shaft.
- Verify all keys, bolts, and pins are in their proper positions. Check all bolts along the motor housing for proper tightness.
- Check any space heaters for proper operation by touching the motor to determine if it is warm before operation.
- Check all surfaces for signs of corrosion.
- Observe the operation of each motor during opening.
- Check motor shafts for normal end play.
- Verify that all motors are smooth-running and free from vibration.
- Check motors and bearings for overheating.
- Note any unusual noises heard during operation. If the motor is fan-cooled, check for proper operation of the fan and that the motor is being properly cooled.
- Check that each motor is wired in accordance with the NEC.
- Verify there is a disconnect switch within sight of each motor.
- Check the internal equipment after disconnecting the motor from its power supply.
- Check electrical connections on the motor for proper attachment.
- Test insulation resistance values on all motors using a megohm meter. Megohm measurements should be taken from phase-to-ground and between phases for all AC, three-phase motors.
- Take megohm measurements at the collector rings to detect cracked or otherwise defective bushings. Readings should be taken using a 500-volt direct current (DC) hand crank or battery-operated megger. Record the results of the megohm meter tests and compare these to prior inspection findings. Any large changes may indicate motor deterioration.
- Recommend overhauling a motor when megohm values for phase-to-ground values are projected to reach 2.0 or less before the next scheduled inspection.
- Recommend that the motor be overhauled as soon as possible if the megohm values are 1.0 or less.

- Check the phase currents in motors under loaded conditions with a clamp-on ammeter for motors of one horsepower or larger. Record the results and compare them to the nameplate data and prior inspection results.
- With the power disconnected, open the inspector ports of the motor to check the interior of the motor. Check that collector rings (slip-rings) are free of carbon, metal dust, discoloration, and deformation. The wearing surface of the collector rings should be smooth, highly polished, and free of dirt, oil, grease, and moisture. Try to determine the source of any detrimental conditions.
- Wound rotor AC motors and synchronous AC motors use brushes to carry current to rotating parts of the motor. For all AC motors:
  - Check that all brushes have free movement within their holders. Each brush holder should be set so the face of the holder is approximately 1/8 inch from the collector ring. Each brush must be reinserted into its original holder and in its original orientation after inspection. It may be helpful to scratch a mark on one side of the brush when removing it to indicate its proper location and alignment.
  - Inspect all brushes for wear. If the remaining portion of any brush within its holder is 1/4 inch or less, the inspector should recommend that all brushes on the motor be replaced.
  - Verify that the entire surface of the brush that rides on the collector ring displays a polished finish, indicating full-surface contact. If a brush is not making full contact over its entire surface, recommend that the brush be re-seated.
  - Inspect the springs that push the brushes against the collector rings. All brushes should be held firmly on the collector ring with approximately the same pressure. Improper spring pressure may lead to collector ring wear or excessive sparking. Recommend that the springs be replaced if this is found.
  - Look for evidence of excessive heat, such as annealed brush springs.

The inspection of electrical span brakes should include the following:

- Check that span brakes are equipped with covers to prevent debris or grease from affecting brake operation.
- Check the mounting and location of limit switches on the brake. Generally, a brake will have a set switch, a release switch, and a hand-released limit switch. Follow the inspection methods listed in Section 4.9.
- Check the wiring in the limit switches.

- Manually operate the hand-release arm to verify that the linkages work properly.
- Check the clearances between the brake shoes and the drum when the brake is released.
- Observe the drum to note the wear pattern. The entire drum should be shiny if it is wearing evenly. Note any uneven wear.
- Make sure no grease, oil, water, or dirt is on the brake drum, as this will reduce braking capacity.
- Check the length of time it takes for the brake to fully release and the brake to set.
- Monitor the brake shoe and drum during operation. If the shoe and drum are not aligned, they will come into contact during operation. This contact could produce smoke and damage the brake.
- Test the insulation of the brake motor with a megohmeter and record the results.

The inspection of warning and barrier gates should include the following:

- Check the exterior of the gate housing for any damage.
- Check the access panels for proper operation.
- Open the housing and inspect for fluid or debris accumulation.
- Closely inspect conduits entering the base of the housing. Oil leaks may flow into the conduits and damage the wiring and environment.
- Inspect the internal equipment.
- Observe the gate arm or barrier during an operation.
- Verify that the flashing lights blink for the duration of the arm's movement. The lights should operate from the time the locks are engaged until the gates are raised.
- Observe the cables powering the flashing lights on the arms.
- Verify the cable is not rubbing against or catching on the gate housing during movement.
- Check the arm for any frayed wire or exposed terminal on the flashing lights. This could pose a danger to a pedestrian.

Gongs are mounted on traffic gates for oncoming traffic. They should be loud. The inspection of gongs should include the following:

- Check that gongs start operating when the warning signals are activated to stop traffic and continue to operate until the locks are released. They should operate again from the time the locks are engaged until the gates are raised.
- Inspect the cables powering the gongs for abrasion or tears.

SECTION 4.9 INSPECTION OF CONTROL SYSTEMS

The inspection of the control desk should include the following:

- Verify that the switchs or pushbuttons used to test the indicator lights on the control desk work. Note any light that operates improperly.
- Operate the bridge several times to verify that all pushbuttons, control switches, indicating lights, meters, and indicators operate properly.
- Record all voltmeter, ammeter, and kilowatt meter readings as the bridge is operated. Compare these readings to the records from previous inspections. Dramatic changes in readings may indicate problems and aid with the inspection.
- Interview several of the bridge operators to determine if they have experienced any problems with the controls or other systems.
- Examine the interior of the control desk. Verify that the interior light is working. Check for any loose wires and inspect the wiring. Look for any scorching or discoloration that could indicate a faulty piece of equipment. Inspect all interior equipment.
- Check all relays, especially plug-in types, to verify that they are firmly installed.
- Check for a strip heater and verify that it is operational.

The inspection of the interlocks should include the following:

- Verify that the interlocks in the control system are operating properly with a series of tests. Extreme care must be taken while verifying the interlocks. Vehicular traffic must be stopped by flagmen while testing roadway equipment. River traffic must be made aware of the testing and any potential delays. The testing must be performed in accordance with the AASHTO *Movable Bridge Inspection, Evaluation, and Maintenance Manual*, as follows:
    - With the bridge in the closed position, perform the following:
        - Attempt to lower the traffic gates prior to sounding the horn or activating the warning lights.
        - With the traffic gate open to vehicular traffic, insert the gate arm hand crank into the traffic gate housing and try to operate the gates from the console. The gate should not operate. Record the results and repeat for all gates.
        - With the locks in place, attempt to operate the bridge span. The span should not operate. Record the results.

  - During the bridge operation, perform the following:
    - For all devices, confirm the motor will not operate if a hand crank is inserted into that device.
    - Confirm that the main motors cannot be started prior to the release of the brakes. The main drive motor starters should not engage. Record the results.
    - Test the limit switches at fully open.
    - Attempt to raise the gates and turn the traffic signals to green before the locks or jacks are fully driven and the bridge span is secure.
    - Verify that the traffic signals cannot be changed to green until all gates are raised.
- Note any problems in the interlocking and clearly notify the operators. The operators in control of the bridge must be aware of any issues found in the inspection.

The inspection of the fuses should include the following:

- Verify the fuses are the proper current rating. The fuse ampacity printed on the side of the fuse should match the ampacity on the as-built wiring diagrams.
- If the fuse ratings do not match the as-built documentation, check the load equipment. If the equipment protected by the fuses has changed, the new equipment may require a different fuse size.
- Verify that the fuse ratings are accurately documented. Inspect the fuse terminals for a tight electrical fit.
- Look for corrosion or scorch marks on the fuse blocks.
- Check for wire used to jumper a fuse, leaving the equipment unprotected, but operational. This condition is not acceptable and must be reported. Note any missing fuses.

The inspection of the circuit breakers should include the following:

- Verify that the trip settings on the circuit breakers are accurate. Compare settings to as-built documentation and equipment ratings.
- Molded-case circuit breakers are not accessible due to their plastic cover. Air circuit breakers should have their arc chutes inspected for debris, missing hardware, and damaged chutes. Check the contact surface for corrosion, pitting, and damage. Operate the circuit breaker to determine whether the contacts make and break contact.
- Check the wiring and terminations.

There are many types of motor controllers ranging from simple contactors to motor drives. The equipment may be installed in a panel or motor control center. The inspection of the circuit breakers should include the following:

- Review the manufacturer's specific written information on the drives on the bridge and follow the inspection recommendations.
- Inspect the motor control panel for any fluid or debris buildup.
- Note any damage to the panel exterior.
- Check the wiring and terminations.
- Inspect the circuit breakers and fuses.
- Inspect the individual contacts for corrosion and scorching.

The inspection of limit switches should include the following:

- Check the wiring and enclosures.
- Note any scratches or damage to the switch exterior.
- Where accessible, open the limit switch and inspect the wiring.
- Inspect the seal of the limit switch and verify that no fluid or debris have accumulated in the housing.
- Check that the limit switches are securely mounted and have little movement or play.
- Lever arm limit switches and plunger-type limit switches have arms that move to trigger the electrical contact. Lever arms rotate around a pivot point in the housing, and plunger-types are pushed into the housing.
    - Inspect the arms for debris, corrosion, and a buildup of dirt.
    - Verify that the arms move freely and do not stick in place. The making and breaking of the limit switch contacts should be audible when testing the arm.
    - Watch the limit switch during a bridge operation.
    - When safe, manually operate the switch to test whether the operation will stop or if the appropriate indicating light energizes.

- Proximity limit switches are generally magnetic sensors that make electrical contact in the presence of a metal trigger.
    - Check the limit switch magnetic sensor for a buildup of magnetic filings that may provide a false indication.
    - When safe, manually operate the switch to test whether the operation will stop or the appropriate indicating light energizes.
- Open the rotary limit switches and inspect the contacts for any corrosion or scorching. Check the bearings for proper lubrication. The rotary limit switch is coupled to the span drive gearing. Inspect these couplings for proper connection.
- Position indicators, selsyn transmitters, resolvers, and tachometers are all feedback devices that provide position or speed information to the operator or to the motor drives. Inspect the enclosures, wiring, and mountings.

The inspection of relays should include the following:

- Verify that relays, especially plug-ins, are securely mounted.
- Verify that all wires and terminals are tagged and identified.
- Check for any jumper wires that are not part of the logical control system. These wires are added to bypass logical control temporarily and should be removed when the equipment has been repaired.
- Note any wiring without tags or wiring that is not documented on the as-built drawings.
- Determine what equipment the relays with jumpers control, and pay close attention to the interlock testing on the control desk when testing that equipment. Relay identifiers should be on nameplates mounted adjacent to the relays and should match the as-built wiring diagrams.
- Inspect the individual relays for contamination, scorch marks, or discoloration and record any relays with these problems.
- Monitor the relays during a bridge operation to verify proper operation. The inspector will be able to hear a short, sharp, click sound as the relays pull in or become engaged.
- Note chattering relays.
- Use a clock to determine if timing relays are operating properly.

The inspection of PLCs should include the following:

- Review any manufacturer's manuals for specific maintenance issues with the particular type of PLC installed on the bridge.
- Small switches on the processor and I/O cards, called dip switches, are configured to allow proper operation. Never change these switches.
- Inspect the processors, I/O cards, and remote racks for any dust, dirt, debris, corrosion, or fluid on the equipment.
- Check the PLC diagnostic lights to see if there are any failures in the equipment.
- Inspect all terminals and wires.
- Inspect the cabinet for debris and fluid, and clean air filters on the fans.
- Check the PLC batteries and make sure they are fully charged.
- Check other equipment in the PLC panel, including fuses, circuit breakers, the heater unit, lights, fans, and relays. Verify proper fan, heater, and light operation. Inspect the filter on the fan for an accumulation of dirt and debris. Inspect other equipment as described in this chapter.

SECTION 4.10 INSPECTION OF LIGHTING SYSTEMS

Test the service lighting throughout the bridge. Note any damaged or inoperative light. Check that lights in machinery areas are equipped with guards and globes. Determine whether the fixture or the bulb is inoperative. Carry a typical light bulb during the inspection to test the fixture.

Use a receptacle tester to verify that the lighting receptacles work and are wired properly. Note any damaged receptacles or any exposed receptacles lacking covers.

Navigation lights will be located along the piers or fender system of the bridge and on the span. The fender navigation lights are red fixtures, while the lights on the span may vary between red only and red and green alternating fixtures.

Check each navigation light for damage, broken lenses, loose mounting, corrosion, and functionality. A night inspection may be necessary. Each light should be clearly visible when lit. Note any fixture that is inoperative or damaged. Inspect any rotating lights for proper range of motion.

Navigation signals consist of horns or public address equipment used to alert waterway traffic. Inspect the equipment for any damage, corrosion, or opened enclosures. Inspect the wiring and verify operation. Inspect all signal devices.